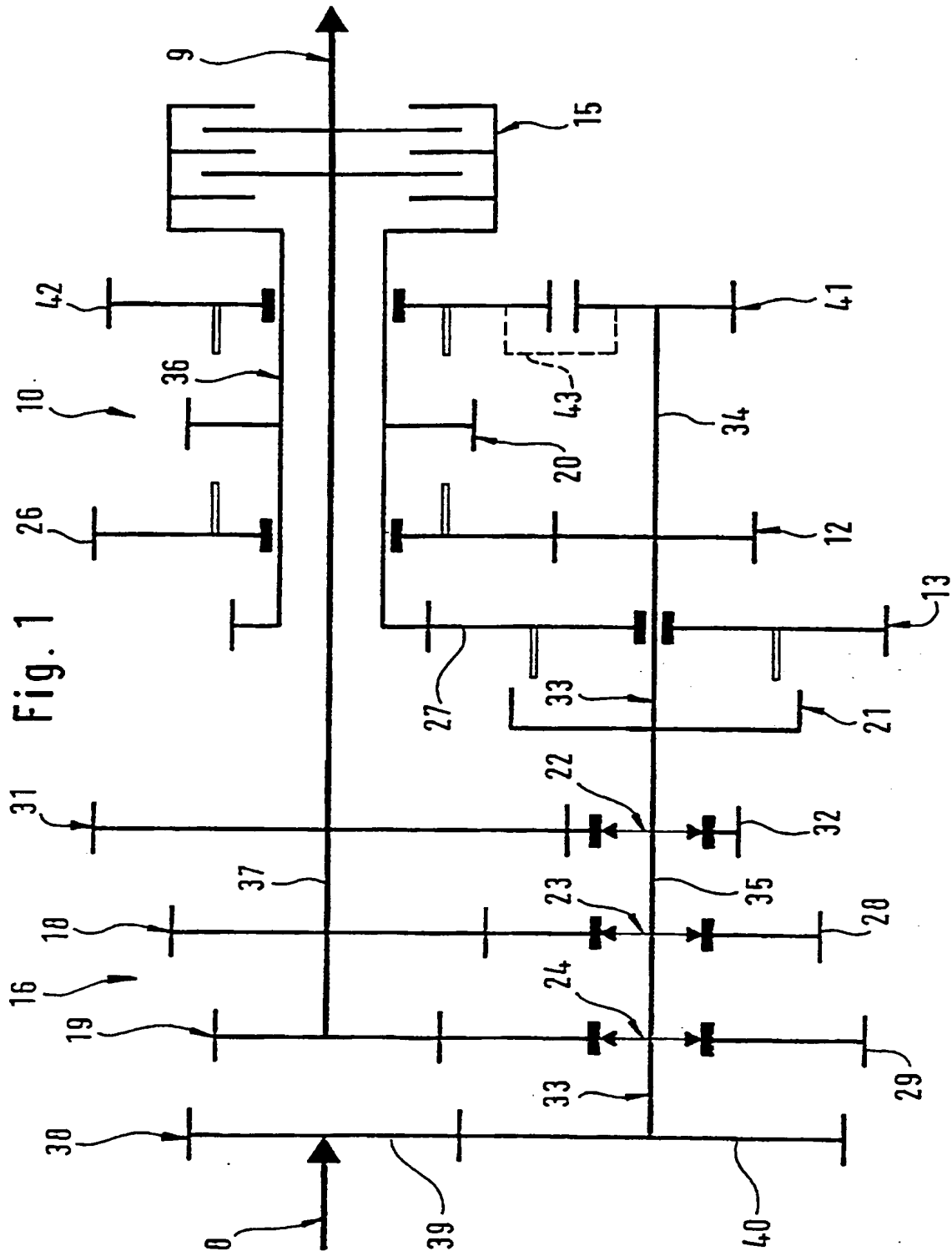


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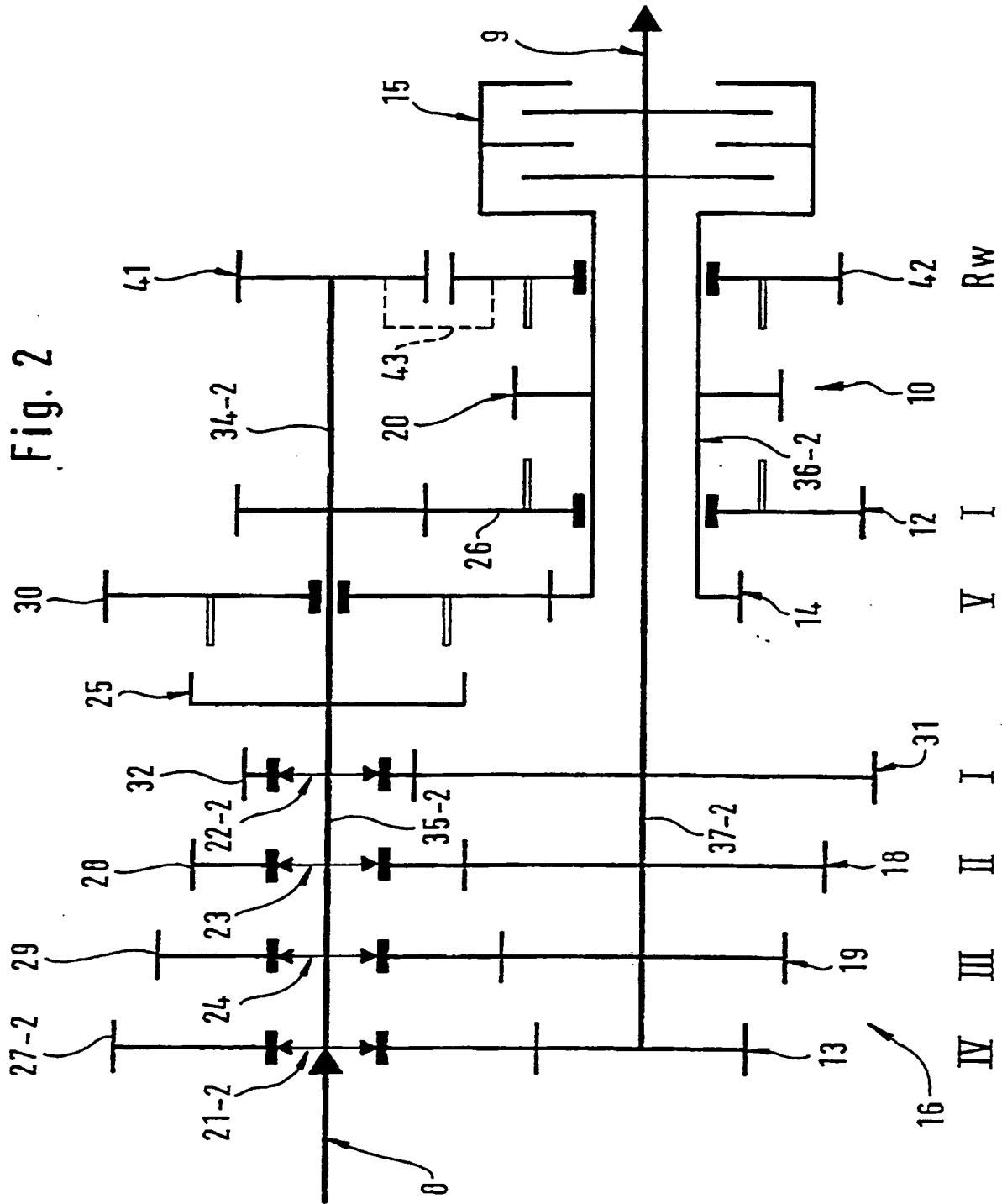
**70 Paul Street, LONDON, EC2A 4NA, United Kingdom**

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III      II      I      IV      I      RW

Fig. 2



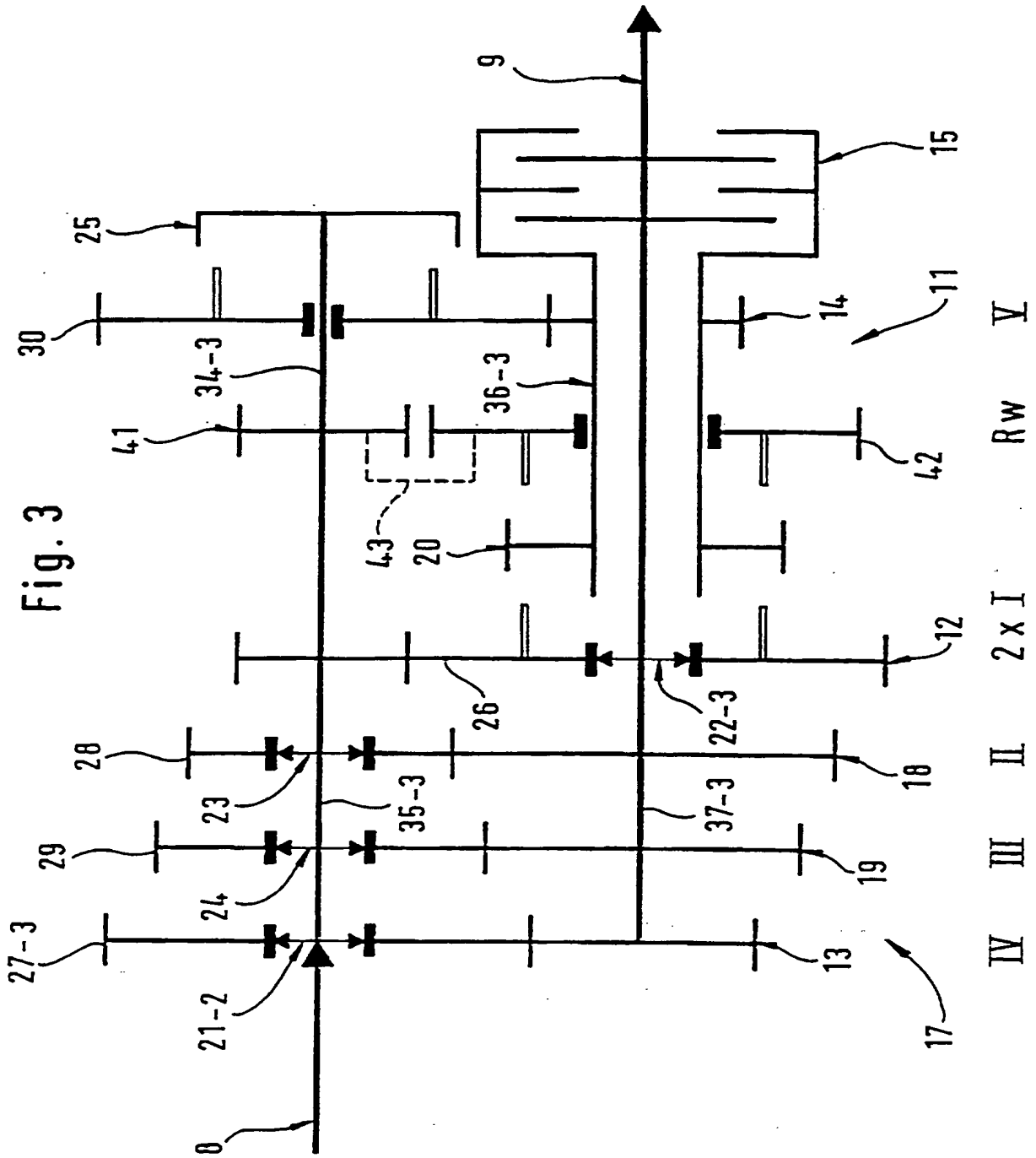
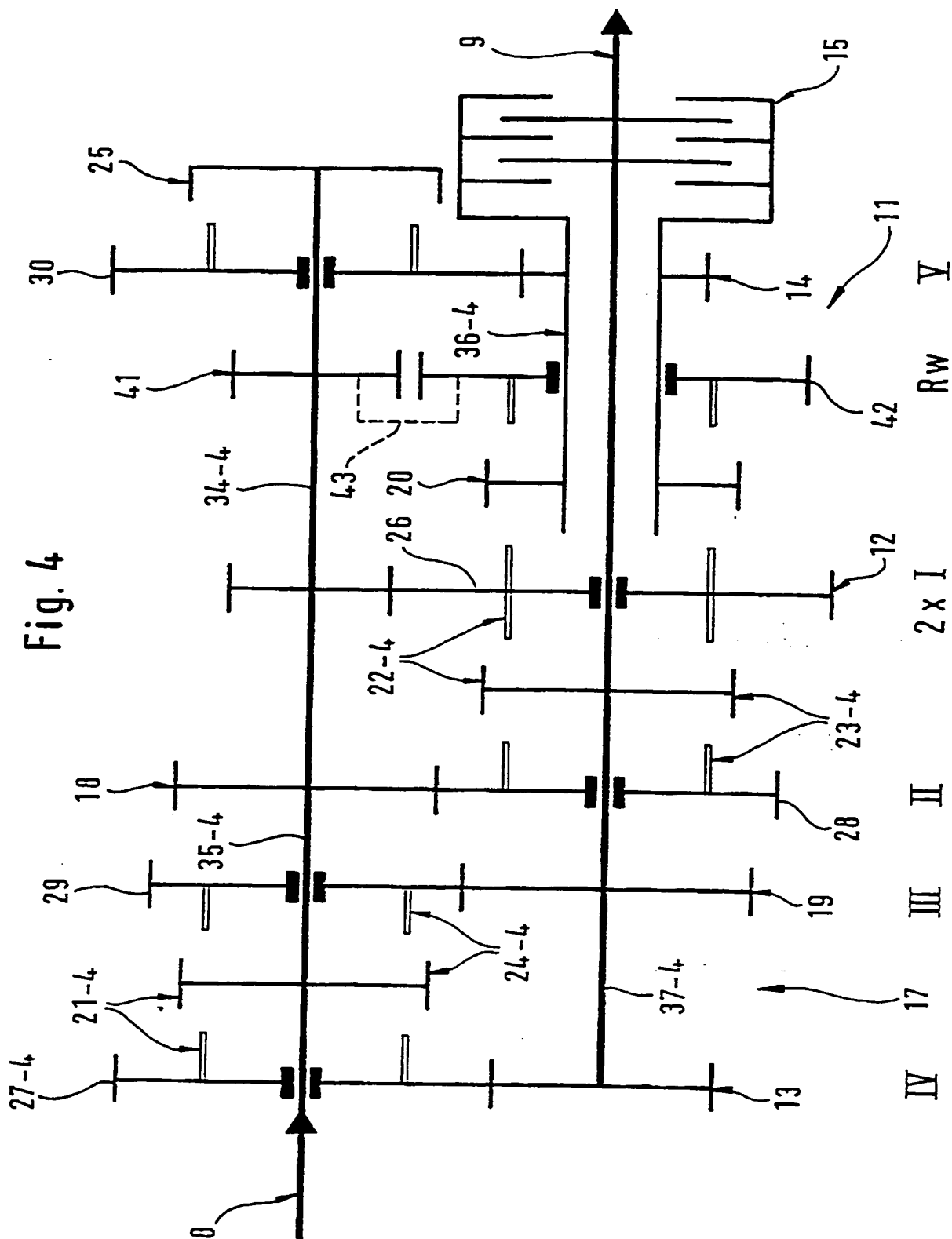


Fig. 4



Multi-speed, multi-path change-speed gearbox

The present invention relates to a multi-speed, multi-path change-speed gearbox.

In a known change-speed gearbox (DE 40 31 851 A1), the first component transmission, which has the gear stage of the lowest forward gear, is also equally assigned the gear stage of the highest forward gear, while the second component transmission has the gear stages of the other forward gears. This assignment is intended to allow gear changes under load despite the use of just one power-shift clutch for the first component transmission only - as opposed to a driving connection only via positive gear clutches for the second component transmission - and thus to eliminate the need for the second power-shift clutch which would otherwise be required for this purpose. For this purpose, the first gear stage of the highest forward gear, the said gear stage belonging to the first component transmission having the power-shift clutch, is used as it were as a splitter for the intermediate transmission of a torque in the intermediate phase of an upshift between the disengagement of the gear clutch of the starting-gear gear stage belonging to the second component transmission and the disengagement of the gear clutch of the target-gear gear stage likewise belonging to the second component transmission. In the case of a drive-away procedure with this known speed-change gearbox, the gear clutch of the gear stage of the lowest forward gear is engaged first, followed by the power-shift clutch, with the transmission capacity increasing. In the steady-state gearbox condition of the lowest forward gear, the power thus flows from the input shaft to the output shaft via the power-shift clutch and the relevant gear stage. With this known change-speed gearbox, however, neither "splitting" with the gear stage of the highest forward gear nor pre-engagement (preselection) of the gear clutch of the second gear is possible in the case of an upshift to the adjacent forward gear - i.e. in the case of a shift from first gear to second gear - because the said clutch belongs to the second component transmission with drive only via positive gear clutches by the input shaft, and the gear stage for first gear belongs to the same first component transmission as the gear stage for the highest gear, with the result that the power-shift clutch has to be disengaged before the gear stage for the first gear - in order to make the latter torque-free - but it is not possible to engage the gear stage for the second gear beforehand because the high differential speed is effective at the latter because of the direct drive only via positive gear clutches by the input shaft. However, the

disengagement of the power-shift clutch is inevitably associated with an interruption in torque transmission, which means a discernible loss of comfort for the vehicle occupants precisely in the case of an upshift between first and second gear due to the very high torques involved.

Independently of this, the prior art also includes change-speed gearboxes of a different class, these including, for example, a sixteen-speed multi-ratio gearbox (US 4,966,048), in which a two-stage main transmission is arranged in series in the power transmission path between an input shaft and an output shaft. The main transmission is connected, on the one hand, to the input shaft by two single-stage subsplitter stages via in each case one frictional, axially engageable and disengageable power-shift clutch and, on the other hand, to the output shaft by two single-stage splitter stages via a two-range transmission arranged after the said stages in the power transmission path. While one subsplitter stage is assigned to the even-numbered forward gears and the other is assigned to the odd-numbered forward gears, the two other splitter stages are engaged in the power transmission path in alternating sequence in, in each case, two forward gears adjacent to one another in terms of their transmission ratio.

In another multi-path change-speed gearbox of a different class belonging to the prior art (US 4,658,663), two component transmissions, each having a gear stage for one and the same third gear are arranged in the power transmission path between an input shaft and an output shaft and are connected to the input shaft via a respective frictional, axially engageable and disengageable power-shift clutch. While one component transmission has further gear stages for a second gear and a fifth gear, the other component transmission also has gear stages for a first gear and a fourth gear. The dual arrangement of the gear stage of the third gear in this change-speed gearbox also permits power shifts between two gears, the gear stages of which would belong to one and the same component transmission given conventional distribution of the gears or gear stages between the component transmission, in which case interruption of torque transmission during a gear change would be inevitable.

Finally, the prior art (DE 35 46 454 A1) also includes another speed-change gearbox of a different class for a motor vehicle with a dual clutch, this gearbox being provided with a central shaft which starts from a first clutch disc and is used to drive a first group of transmission ratios, and with a shorter hollow shaft, which is concentric with the central shaft, starts from a second clutch disc and is used to drive a

second group of transmission ratios. In order to reduce the amount of installation space for the dual clutch and obtain a good response, the clutch discs are embodied with as small a mass as possible according to this publication. However, since this reduces the heat storage capacity of a clutch disc, the clutch disc may overheat when driving the motor vehicle away. In order to prevent a clutch disc being heated to an impermissible high temperature, the hollow shaft and the central shaft in this known power-shift transmission can be connected to one another in a rotationally rigid manner by a clutch arranged between them, allowing both clutch discs to be used jointly when driving the motor vehicle away.

The present invention seeks essentially to permit "splitting" with the gear stage of the highest forward gear even in the case of shifts from first gear to second gear while maintaining the drive only via positive gear clutches for the component transmission having the gear stages for higher forward gears, ensuring that these shifts too are inherently power shifts.

According to one aspect of the present invention there is provided a multi-speed multi-path change-speed gearbox in which a first component transmission, which has a respective gear stage for the formation of the lowest and the highest forward gear and can be brought into driving connection with the input or the output shaft by means of a frictional power-shift clutch, and a second component transmission, which has both at least one gear stage for the formation of a respective associated further forward gear and is in driving connection only via positive gear clutches with the input shaft, can be connected individually or jointly into the power transmission path between an input and an output shaft, and in which the respective power transmission path can be established in the component transmissions by engaging a positive gear clutch for coupling a free gear of an associated gear stage to its shaft, and in which, in a drive-away procedure, both the gear clutch of the lowest forward gear of the first component transmission and the power-shift clutch of the latter are engaged, wherein the second component transmission has an additional gear stage for the formation of the transmission ratio of the lowest forward gear (first gear) with an associated additional gear clutch for coupling its free gear to its shaft, and, in the steady-state condition of the lowest forward gear, the power-shift clutch is disengaged and the additional gear clutch of the lowest forward gear (first gear) is engaged.

According to a second aspect of the present invention there is provided a multi-speed multi-path change-speed gearbox in which a first component transmission, which has a respective gear stage for the formation of the lowest and the highest forward gear and can be brought into driving connection with the input or the output shaft by means of a frictional power-shift clutch, and a second component transmission, which has both at least one gear stage for the formation of a respective associated further forward gear and is in continuous direct driving connection with the input shaft, can be connected individually or jointly into the power transmission path between an input and an output shaft, and in which the respective power transmission path can be established in the component transmissions by engaging a positive gear clutch for coupling a free gear of an associated gear stage to its shaft, and in which, in a drive-away procedure, both the gear clutch of the lowest forward gear of the first component transmission and the power-shift clutch of the latter are engaged, and in which one shaft of two mutually concentric shafts that can be coupled to one another by the power-shift clutch is assigned one gear of the gear stages of one component transmission and the other shaft is assigned one gear of the gear stages of the second component transmission, wherein both the free gear of the gear stage of the lowest forward gear (first gear) and a gear clutch additionally connected to this free gear are arranged coaxially with the mutually concentric shafts and this free gear can optionally be coupled to the mutually concentric shafts via its two gear clutches.

For the steady-state condition of the lowest forward gear in the change-speed gearbox according to the first aspect of the invention, the gear stage which is additional in this case - i.e. as with the other forward gears with the exception of the higher forward gear a gear stage of the second component transmission with a driving connection only via positive gear clutches to the input shaft is used, allowing the gear stage of the highest forward gear, the said gear stage belonging to the first component transmission connected to the power-shift clutch, to be connected phase-wise into the power transmission path, as a splitter as it were, in the case of all upshifts equally, i.e. even in the case of an upshift to second gear.

The same mode of operation is achieved with the change-speed gearbox according to the second aspect of the invention since, in this gearbox, the gear stage of the lowest forward gear can be connected into the power transmission path of the second component transmission with a direct driving connection to the input shaft only via positive gear clutches by means of its additional gear clutch in the steady-state condition

of the lowest forward gear, allowing the gear stage of the highest forward gear, the said gear stage belonging to the first component transmission with connection to the power-shift clutch, to be involved phase-wise as a splitter in the gear-change operation.

The subject matter of Patent Claim 3 is an embodiment of a change-speed gearbox according to one or the other aspects of the invention, this embodiment having an advantageously short axial length.

Patent Claim 4 relates to an advantageous refinement and incorporation into the gearbox of the additional gear clutch of the lowest forward gear in a change-speed gearbox according to the other invention in accordance with the second aspect.

The method according to Patent Claim 5 relates to an advantageous way of gear changing during the drive-away process in a change-speed gearbox according to one or the other of the aspects, a variant of this method relates to the completion of the drive-away process and forms the subject matter of Patent Claim 6.

The method according to Patent Claim 7 for gear changing in a change-speed gearbox relates to the steady-state condition of the gearbox in the forward gears assigned to the second component transmission and allows delay-free power shifting to the adjacent higher forward gear.

The method according to Patent Claim 8 for gear changing in a change-speed gearbox according to one or the other aspects of the invention relates to advantageous upshifts, in each case in the form of a power shift between the forward gears associated with the second component transmission, including the lowest forward gear.

The method according to Patent Claim 9 relates to an advantageous upshift in traction mode to the highest forward gear in a change-speed.

The method according to Patent Claim 10 for shifting in a change-speed gearbox relates to an advantageous downshift in traction mode from the highest forward gear.

The method according to Patent Claim 11 for gear changing in a change-speed gearbox relates to advantageous downshifts in traction mode between two of the forward gears associated with the second component transmission, including the lowest forward gear.

And, finally, the method according to Patent Claim 12 for gear changing in a change-speed gearbox relates to advantageous downshifts in overrun mode between two

forward gears associated by means of its gear clutch to the second component transmission, including the lowest forward gear.

The invention is explained in greater detail below with reference to two respective embodiments illustrated to a greater or lesser extent schematically in the drawing, in which:

Fig. 1 shows a gearbox diagram of a four-speed two-path change-speed gearbox according to one aspect of the invention in a first embodiment,

Fig. 2 shows a gearbox diagram of a five-speed two-path change-speed gearbox according to one invention in a second embodiment,

Fig. 3 shows a gearbox diagram of a five-speed two-path change-speed gearbox according to the other aspect of the invention in a first, and

Fig. 4 shows a gearbox diagram of a five-speed two-path change-speed gearbox according to the other aspect of the invention in a second embodiment.

Referring to Figure 1, a change-speed gearbox has an input shaft 8, a coaxial output shaft 9 and a layshaft 33 parallel to the input shaft 8. The layshaft 33 is driven by the input shaft 8 via a constantly engaged gear 38 which comprises two intermeshing gears 39 and 40, the input-side gear 39 being seated concentrically and in a rotationally rigid manner on the input shaft 8 and gear 40 being seated concentrically and in a rotationally rigid manner on the layshaft 33. A first component transmission 10 with a gear stage 12 for the formation of the lowest forward-gear ratio (in all four embodiments this is the first gear), with a gear stage 13 for the formation of the highest forward-gear ratio - in this embodiment this is the fourth gear - and with a gear stage 41 for the formation of a reverse-gear ratio, and a second component transmission 16 with a gear stage 18 for the formation of the second-gear ratio, a gear stage 19 for the formation of the third-gear ratio and an additional gear stage 31, likewise for the formation of the lowest gear ratio, i.e. the first-gear ratio, can be connected into the power transmission path between the input shaft 8 via the layshaft 33, on the one hand, and the output shaft 9, on the other hand.

The input of the first component transmission 10 is formed by an intermediate shaft 34, which is arranged coaxially with the layshaft 33 and is rotationally rigid with the latter. The output of the first component transmission 10 is formed by an intermediate shaft 36 in the form of a hollow shaft, which is arranged coaxially with the output shaft 9 and is rotationally rigid with the latter and can be coupled to it by a power-

shift clutch 15. The fixed gear of gear stage 12, the said gear being arranged concentrically and in a rotationally rigid manner on the intermediate shaft 34, meshes with a free gear 26, which is arranged concentrically with the intermediate shaft 36 and can be coupled to the latter by means of a changing gear clutch 20.

The fixed gear of gear stage 13, the said fixed gear being arranged concentrically and in a rotationally rigid manner on the intermediate shaft 36, meshes with a free gear 27, which is arranged concentrically and in a rotationally rigid manner on intermediate shaft 34 and can be coupled to the latter by a gear clutch 21.

The free gear 42 of gear stage 41 is arranged concentrically and in a rotationally rigid manner with respect to intermediate shaft 36 and can be coupled to the latter by the changing gear clutch 20. The free gear 42 meshes in a known manner indicated in dashed lines at 43 with an intermediate gear which effects the reversal in the direction of rotation and, for its part, meshes with the fixed gear of gear stage 41, the said gear being arranged concentrically and in a rotationally rigid manner on intermediate shaft 34.

The input of the second component transmission 16 is formed by an intermediate shaft 35, which is arranged concentrically and in a rotationally rigid manner with respect to the layshaft 33. The output of the second component transmission 16 is formed by an intermediate shaft 37, which is arranged coaxially and in a rotationally rigid manner with respect to the output shaft 9.

The free gear 28 of gear stage 18, which meshes with a fixed gear seated concentrically in a rotationally rigid manner on intermediate shaft 37, is arranged concentrically and rotatably on the intermediate shaft 35 and can be coupled to the latter by a gear clutch 23 that can be engaged and disengaged radially.

The free gear 29 of gear stage 19, which meshes with a fixed gear seated concentrically and in a rotationally rigid manner on an intermediate shaft 37, is arranged concentrically and rotatably on intermediate shaft 35 and can be coupled to the latter by a gear clutch 24 that can be engaged and disengaged radially.

The free gear 32 of gear stage 31, which meshes with a fixed gear seated concentrically and in a rotationally rigid manner on intermediate shaft 37, is arranged concentrically and rotatably on intermediate shaft 35 and can be coupled to the latter by a gear clutch 22 that can be engaged and disengaged radially.

Referring to Figure 2, a change-speed gearbox has an input shaft 8 and a parallel output shaft 9. A first component transmission 10 having the three gear stages 12, 14 and 41, and a second component transmission 16, having four gear stages 13, 18, 19 and 31, can be connected into the power transmission path between these shafts.

An intermediate shaft 34-2, which is coaxial and rotationally rigid with respect to the input shaft 8, is used for the input of the first component transmission 10. An intermediate shaft 36-2 in the form of a hollow shaft which is arranged concentrically and rotatably with respect to the output shaft 9 and can be coupled to the latter by a power-shift clutch 15 is used for the output of the first component transmission 10.

An intermediate shaft 35-2 which is arranged coaxially and in a rotationally rigid manner with respect to the input shaft 8 is used for the input of the second component transmission 16. An intermediate shaft 37-2 which is arranged coaxially and in a rotationally rigid manner with respect to the output shaft 9 is used for the output of component transmission 16.

The free gear 26 of the gear stage 12 for the formation of the lowest forward-gear ratio, which meshes with a fixed gear seated concentrically and in a rotationally rigid manner on intermediate shaft 34-2, is arranged concentrically and rotatably with respect to intermediate shaft 36-2 and can be coupled to the latter by means of a changing gear clutch 20.

The free gear 30 of the gear stage 14 for the formation of the highest forward-gear ratio - in this case this is fifth gear - meshes with a fixed gear seated concentrically and in a rotationally rigid manner on intermediate shaft 36-2. The free gear 30 is furthermore arranged coaxially and rotatably on intermediate shaft 34-2 and can be coupled to the latter by means of a gear clutch 25.

The free gear 42 of the gear stage 41 for the formation of a reverse-gear ratio is arranged concentrically and rotatably with respect to intermediate shaft 36-2 and can be coupled to the latter by means of the changing gear clutch 20. The free gear 42 furthermore meshes in a known manner indicated in dashes at 43 with an intermediate gear which effects a reversal in the direction of rotation and, for its part, meshes with the fixed gear of gear stage 41, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 34-2.

The free gear 27-2 of the gear stage 13 for the formation of the fourth-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-2 and can be

coupled to the latter by a gear clutch 21-2 that can be engaged and disengaged radially. The free gear 27-2 furthermore meshes with a fixed gear of gear stage 13, which is seated concentrically and in a rotationally rigid manner on intermediate shaft 37-2.

The free gear 28 of the gear stage 18 for the formation of the second-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-2 and can be coupled to the latter by means of a gear clutch 23 that can be engaged and disengaged radially. The free gear 28 furthermore meshes with a fixed gear of gear stage 18, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-2.

The free gear 29 of the gear stage 19 for the formation of the third-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-2 and can be coupled to the latter by means of a gear clutch 24 that can be engaged and disengaged radially. Free gear 29 meshes with a fixed gear of gear stage 19, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-2.

The free gear 32 of the additional gear stage 31 for the formation of the lowest forward-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-2 and can be coupled to the latter by means of an additional gear clutch 22-2, which can be engaged and disengaged radially. Free gear 32 meshes with a fixed gear of gear stage 31, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-2.

Referring to the embodiment in Figure 3, a change-speed gearbox has an input shaft 8 and a parallel output shaft 9 which can be brought into mutual driving connection by a first component transmission 11, having gear stages 12, 14 and 41, and/or by a second component transmission 17, having gear stages 12, 13, 18 and 19.

For the input of the first component transmission 11, an intermediate shaft 34-3 is provided, this being arranged coaxially and in a rotationally rigid manner with respect to the input shaft 8. For the output of the first component transmission 11, an intermediate shaft 36-3 is provided, this being arranged concentrically and rotatably with respect to the output shaft 9 and being capable of being coupled to the latter by means of a power-shift clutch 15.

For the input of the second component transmission 17, use is made of an intermediate shaft 35-3 which is arranged coaxially and in a rotationally rigid manner with respect to the input shaft 8. For the output of the second component transmission 17,

an intermediate shaft 37-3 is provided, this shaft being arranged coaxially and in a rotationally rigid manner with respect to the output shaft 9.

The free gear 26 of the gear stage 12 for the formation of the lowest forward-gear ratio (first gear) is arranged both coaxially and rotatably with respect to the concentric shafts 36-3 and 37-3, allowing it to be coupled by a first gear clutch in the form of a changing gear clutch 20 to intermediate shaft 36-3 and consequently to be associated with the first component transmission 11 and to be coupled by an additional second gear clutch 22-3 in the form of a clutch that can be engaged and disengaged radially to intermediate shaft 37-3 and consequently to be associated also with the second component transmission 17.

The free gear 30 of the gear stage 14 for the formation of the highest forward-gear ratio (fifth gear) is arranged coaxially and rotatably with respect to intermediate shaft 34-3 and can be coupled to the latter by means of a gear clutch 25. Free gear 30 also meshes with a fixed gear of gear stage 14, the said gear being arranged coaxially and in a rotationally rigid manner with respect to intermediate shaft 36-3.

The free gear 42 of the gear stage 41 for the formation of a reverse-gear ratio is arranged concentrically and rotatably with respect to intermediate shaft 36-3 and can be coupled to the latter by means of the changing gear clutch 20. Free gear 42 meshes in the known manner indicated in dashes at 43 with an intermediate gear which effects a reversal in the direction of rotation and, for its part, meshes with a fixed gear of gear stage 41, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 34-3.

The free gear 27-3 of the gear stage 13 for the formation of the fourth-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-3 and can be coupled to the latter by means of a gear clutch 21-2 that can be engaged and disengaged radially. Free gear 27-3 meshes with a fixed gear of gear stage 13, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-3.

The free gear 28 of the gear stage 18 for the formation of the second-gear ratio is arranged concentrically and rotatably on intermediate shaft 35-3 and can be coupled to the latter by means of a gear clutch 23 that can be engaged and disengaged radially. Free gear 28 meshes with a fixed gear of gear stage 18, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-3.

The free gear 29 of the gear stage 19 for the formation of the third-gear ratio is arranged concentrically and rotatably on the intermediate shaft 35-3 and can be coupled to the latter by means of a gear clutch 24 that can be engaged and disengaged radially. Free gear 29 meshes with a fixed gear of gear stage 19, the said gear being seated concentrically and in a rotationally rigid manner on intermediate shaft 37-3.

The additional, radially engageable and disengageable gear clutch 22-3 for associating the gear stage 12 for the formation of the lowest forward-gear ratio with the second component transmission 17 and the radially engageable and disengageable gear clutch 23 of the free gear 28 of the gear stage 18 for the formation of the second-gear ratio of the embodiment in Figure 3 are replaced in the embodiment in Figure 4 by an axially engageable and disengageable changing gear clutch 22-4/23-4 provided on the intermediate shaft 37-4 which forms the output of the second component transmission 17 and is arranged coaxially and in a rotationally rigid manner with respect to the output shaft 9, that gear of gear stage 18 which is seated on the intermediate shaft in this case being used as free gear 28.

The gear clutches 21-2 and 24 of gear stages 13 and 19 of the embodiment in Figure 3, the said clutches each being radially engageable and disengageable, are replaced in the embodiment in Figure 4 by an axially engageable and disengageable changing gear clutch 21-4/24-4.

Otherwise, the two embodiments in Figures 3 and 4 are identical in their construction and mode of operation.

In the embodiments of the invention in accordance with Patent Claim 1 (Figures 1 and 2), the gear-change sequences are identical.

In the embodiments of the invention in accordance with Patent Claim 2 (Figures 3 and 4), the gear-change sequences are identical.

The gear-change sequences in the invention in accordance with Patent Claim 1 are analogous to the gear-change sequences in the invention in accordance with Patent Claim 2.

The most important gear-change sequences are described below with reference to the embodiments in Figures 2 and 3, the expressions in brackets relating to the relevant gear-change element of the embodiment in Figure 3.

Drive-away procedure:

First of all, the gear clutch 20-26 of the gear stage 12 for the first gear, the said clutch being associated with the first component transmission 10(11), and then the power-shift clutch 15 are engaged as the drive-away element. As the differential speed approaches zero at the gear clutch 22-2 (22-3) of the gear stage 31(12) of the first gear, the said clutch being associated with the second component transmission 16(17), this clutch is engaged. The power-shift clutch 15 is then disengaged, the steady-state condition of the first gear thus having been achieved.

To prepare an upshift, the gear clutch 25 of the highest forward gear V can be engaged in addition.

#### Upshift I-II in traction mode:

With gear clutch 25 engaged, the power-shift clutch 15 is engaged with a continuously increasing transmission capacity and, when the gear clutch 22-2(22-3) of the first gear has thereby been relieved of load, it is disengaged. The speed of the input shaft 8 is then adjusted to the synchronization speed associated with the second gear by controlling the transmission capacity of the power-shift clutch 15 - optionally with additional regulation of the engine - and, as the differential speed at the gear clutch 23 of the second gear approaches zero as a result, this clutch is engaged. The power-shift clutch 15 is then disengaged, the steady-state condition of the second gear thus having been established.

All upshifts in traction mode between the forward gears I to IV associated with the second component transmission 16(17) proceed in analogous fashion to the I-II upshift described above.

#### IV-V upshift in traction mode:

With gear clutch 25 engaged, the power shift clutch 15 is engaged with its transmission capacity increasing continuously and, when the gear clutch 21-2

The most important gear-change sequences are described below with reference to the embodiments in Figures 2 and 3, the expressions in brackets relating to the relevant gear-change element of the embodiment in Figure 3.

#### Drive-away procedure:

First of all, the gear clutch 20-26 of the gear stage 12 for the first gear, the said clutch being associated with the first component transmission 10(11), and then the power-shift clutch 15 are engaged as the drive-away element. As the differential speed approaches zero at the gear clutch 22-2 (22-3) of the gear stage 31(12) of the first gear,

the said clutch being associated with the second component transmission 16(17), this clutch is engaged. The power-shift clutch 15 is then disengaged, the steady-state condition of the first gear thus having been achieved.

To prepare an upshift, the gear clutch 25 of the highest forward gear V can be engaged in addition.

Upshift I-II in traction mode:

With gear clutch 25 engaged, the power-shift clutch 15 is engaged with a continuously increasing transmission capacity and, when the gear clutch 22-2(22-3) of the first gear has thereby been relieved of load, it is disengaged. The speed of the input shaft 8 is then adjusted to the synchronization speed associated with the second gear by controlling the transmission capacity of the power-shift clutch 15 - optionally with additional regulation of the engine - and, as the differential speed at the gear clutch 23 of the second gear approaches zero as a result, this clutch is engaged. The power-shift clutch 15 is then disengaged, the steady-state condition of the second gear thus having been established.

All upshifts in traction mode between the forward gears I to IV associated with the second component transmission 16(17) proceed in analogous fashion to the I-II upshift described above.

IV-V upshift in traction mode:

With gear clutch 25 engaged, the power shift clutch 15 is engaged with its transmission capacity increasing continuously and, when the gear clutch 21-2 of the fourth gear has been relieved of load as a result, it is disengaged. The speed of the input shaft 8 is then adjusted to the synchronization speed associated with the fifth gear by controlling the transmission capacity of the power-shift clutch 15 - optionally with additional regulation of the engine - and the transmission capacity is then increased to a value associated with the instantaneous engine operating point, the steady-state condition of the fifth gear thus having been achieved.

V-IV downshift in traction mode:

The transmission capacity of the power-shift clutch 15 is reduced until slip occurs and the gear clutch 25 of the fifth gear is then disengaged - if appropriate with a brief reduction in the transmission capacity to zero. The speed of the input shaft 8 is then adjusted to the synchronization speed associated with fourth gear by controlling the

transmission capacity, preferably with additional regulation of the engine, and when the differential speed at the gear clutch 21-2 of the fourth gear approaches zero, the said clutch is engaged. The power-shift clutch 15 is then disengaged and the steady-state condition of the fourth gear has thus been established.

#### III-II downshift in traction mode:

With gear clutch 25 engaged, the power-shift clutch 15 is engaged with a continuously increasing transmission capacity and, when the gear clutch 24 of the third gear has thereby been relieved of load, it is disengaged. The speed of the input shaft 8 is then adjusted to the synchronization speed associated with second gear by controlling the transmission capacity of the power-shift clutch 15, preferably with additional regulation of the engine, and, when the differential speed at the gear clutch 23 of the second gear approaches zero as a result, the said clutch is engaged. The power-shift clutch 15 is then disengaged and the steady-state condition of the second gear has thus been established.

All downshifts in traction mode between the forward gears I to IV associated with the second component transmission 16(17) proceed in analogous fashion to the downshift described above.

### Claims

1. A multi-speed multi-path change-speed gearbox in which a first component transmission, which has a respective gear stage for the formation of the lowest and the highest forward gear and can be brought into driving connection with the input or the output shaft by means of a frictional power-shift clutch, and a second component transmission, which has both at least one gear stage for the formation of a respective associated further forward gear and is in driving connection only via positive gear clutches with the input shaft, can be connected individually or jointly into the power transmission path between an input and an output shaft, and in which the respective power transmission path can be established in the component transmissions by engaging a positive gear clutch for coupling a free gear of an associated gear stage to its shaft, and in which, in a drive-away procedure, both the gear clutch of the lowest forward gear of the first component transmission and the power-shift clutch of the latter are engaged, wherein the second component transmission has an additional gear stage for the formation of the transmission ratio of the lowest forward gear (first gear) with an associated additional gear clutch for coupling its free gear to its shaft, and, in the steady-state condition of the lowest forward gear, the power-shift clutch is disengaged and the additional gear clutch of the lowest forward gear (first gear) is engaged.

2. A multi-speed multi-path change-speed gearbox in which a first component transmission, which has a respective gear stage for the formation of the lowest and the highest forward gear and can be brought into driving connection with the input or the output shaft by means of a frictional power-shift clutch, and a second component transmission, which has both at least one gear stage for the formation of a respective associated further forward gear and is in continuous direct driving connection with the input shaft, can be connected individually or jointly into the power transmission path between an input and an output shaft, and in which the respective power transmission path can be established in the component transmissions by engaging a positive gear clutch for coupling a free gear of an associated gear stage to its shaft, and in which, in a drive-away procedure, both the gear clutch of the lowest forward gear of the first component transmission and the power-shift clutch of the latter are engaged, and in which one shaft of two mutually concentric shafts that can be coupled to one another by the power-shift

clutch is assigned one gear of the gear stages of one component transmission and the other shaft is assigned one gear of the gear stages of the second component transmission, wherein both the free gear of the gear stage of the lowest forward gear (first gear) and a gear clutch additionally connected to this free gear are arranged coaxially with the mutually concentric shafts and this free gear can optionally be coupled to the mutually concentric shafts via its two gear clutches.

3. A change-speed gearbox according to Patent Claim 1 or 2, wherein the additional gear clutch of the lowest forward gear (first gear) comprises a radially engageable and disengageable clutch.

4. A change-speed gearbox according to Patent Claim 2, wherein the additional gear clutch comprises an axially engageable and disengageable changeover clutch and is connected not only to the free gear of the gear stage of the lowest forward gear (first gear) but also with a free gear of a further gear stage of the second component transmission.

5. A method for gear changing in a change-speed gearbox according to any one of Claims 1 to 4, wherein, in the drive-away procedure, the gear clutch of the lowest forward gear (first gear), the said clutch being associated with the first component transmission, is engaged first and a power-shift clutch is then engaged, preferably with a continuously increasing transmission capacity, and when the differential speed in the additional gear clutch of the lowest forward gear approaches zero, this gear clutch is engaged, and, in the engaged state of the additional gear clutch of the lowest forward gear, the power-shift clutch is disengaged, preferably with a continuous reduction in its transmission capacity.

6. A method according to Claim 5 for gear changing in a change-speed gearbox according to any one of Claims 1 to 4, the gear clutch of the lowest forward gear (first gear), the said clutch being associated with the first component transmission, is disengaged after the disengagement of the power-shift clutch at the end of the drive-away procedure.

7. A method according to Patent Claim 5 or 6, wherein the gear clutch of the highest forward gear (IV or V) is engaged or brought into engagement in the steady-state condition of the forward gears (I to III or IV) associated by their gear clutch with the second component transmission, including the lowest forward gear.

8. A method according to Patent Claim 7, wherein, in a first gear-change phase in the case of an upshift in traction mode between two forward gears which are adjacent in terms of their transmission ratio and are associated by their gear clutch with the second component transmission, including the lowest forward gear (first gear), the power-shift clutch is engaged, preferably with a continuously increasing transmission capacity, and, when the gear clutch of the gear stage of the lower forward gear is torque-free, this gear clutch is disengaged, in a further gear-change phase, the speed of the input shaft is adjusted to the synchronization speed corresponding to the higher forward gear by influencing the transmission capacity of the power-shift clutch, optionally with additional regulation of the engine, and, as the differential speed of the gear clutch of the gear stage of the higher forward gear approaches zero, this gear clutch is engaged, and, in a further gear-change phase, the transmission capacity of the power-shift clutch is adjusted towards zero, preferably in a continuous manner.

9. A method according to Patent Claim 7, wherein, in a first gear-change phase in the case of an upshift in traction mode to the highest forward gear (fourth or fifth gear) from the lower forward gear (third or fourth gear) which is adjacent in terms of its transmission ratio, the power-shift clutch is engaged while its transmission capacity is increased, preferably in a continuous manner, and, when the gear clutch of the lower forward gear is load-free as a result, this gear clutch is disengaged, in a further gear-change phase, the speed of the input shaft is adjusted to the synchronization speed associated with the highest forward gear by controlling the transmission capacity of the power-shift clutch, optionally with supporting regulation of the engine speed, and the transmission capacity of the power-shift clutch is then adjusted to a value associated with the instantaneous engine operating point.

10. A method for gear changing in a change-speed gearbox according to any one of Patent Claims 1 to 4, wherein, in a first gear-change phase in the case of a

downshift in traction mode from the highest forward gear (fourth or fifth gear) to the lower forward gear (third or fourth gear) which is adjacent in terms of its transmission ratio, the transmission capacity of the power-shift clutch is reduced until clutch slip occurs, and the gear clutch of the highest forward gear is disengaged, preferably with a brief reduction of the transmission capacity of the power-shift clutch to zero, and, in a further gear-change phase, the speed of the input shaft is adjusted to the synchronization speed associated with the lower forward gear by controlling the transmission capacity of the power-shift clutch, optionally by supporting regulation of the engine speed, and, when the differential speed at the gear clutch of the lower forward gear approaches zero as a result, this gear clutch is engaged, and, in a further gear-change phase, the transmission capacity of the power-shift clutch is adjusted towards zero.

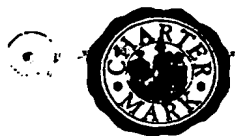
11. A method according to Patent Claim 7 wherein, in a first gear-change phase in the case of a downshift in traction mode between two forward gears associated by means of their gear clutch with the second component transmission, including the lowest forward gear, the power-shift clutch is first of all engaged, with its transmission capacity preferably rising continuously, and when the gear clutch of the higher forward gear is load-free as a result, this gear clutch is disengaged, in a further gear-change phase, the speed of the input shaft is adjusted to the synchronization speed associated with a lower forward gear by controlling the transmission capacity of the power-shift clutch, optionally with additional regulation of the engine speed, and, when the differential speed at the gear clutch of the lower forward gear approaches zero as a result, this gear clutch is engaged, and, in a further gear-change phase, the transmission capacity of the power-shift clutch is adjusted towards zero.

12. A method for gear changing in a change-speed gearbox according to any one of Patent Claims 1 to 4, wherein, in a first gear-change phase in the case of a downshift in overrun mode between two forward gears associated by means of their gear clutch with the second component transmission, including the lowest forward gear, the gear clutch of the highest forward gear (IV or V) is disengaged and the gear clutch of the lowest forward gear, the said gear clutch being associated with the first component transmission), is engaged, and, in a further gear-change phase, the power-shift clutch is engaged with a transmission capacity which preferably rises continuously and, when the

gear clutch of the higher forward gear is load-free as a result, this gear clutch is disengaged, and, in a further gear-change phase, the speed of the input shaft is adjusted to the synchronization speed associated with the higher forward gear by controlling the transmission capacity of the power-shift clutch, optionally by additional regulation of the engine speed, and, when the differential speed at the gear clutch of the lower forward gear approaches zero as a result, this gear clutch is engaged, and, in a further gear-change phase, the transmission capacity of the power-shift clutch is adjusted towards zero.

13.           A multi-speed multi-path change-speed gearbox, substantially as described herein, with reference to and as illustrated in the accompanying drawings.

14.           A method for gear changing in a change-speed gearbox according to claim 13 and as described herein.



Application No: GB 9925951.7  
Claims searched: 1 to 14

Examiner: Mike Mckinney  
Date of search: 21 January 2000

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.R): F2D (DTF, DTG, DTP, DTR).  
Int Cl (Ed.7): F16H 3/00, 3/08, 3/087, 3/091.  
Other: ONLINE: WPI; EPODOC; JAPIO.

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2186333 A (AUTOMOTIVE PRODUCTS)	
A	EP 0061845 A2 (AUTOMOTIVE PRODUCTS)	
A	US 4485687 (BURKE et al)	

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